



## Chapter Seven

# Measuring Pollution Prevention

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- **Guest Comments:**  
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## Introduction

The chapter discusses the two key aspects of measuring pollution prevention results: assessing program effectiveness and determining pollution reductions. Evaluations of pollution prevention program effectiveness have been undertaken in the last few years by some of the more established state programs. Questions asked are typical of program evaluations in other fields: Are we reaching the right people? Are information and technologies being disseminated and used? Are program personnel adequately trained to deal with the program's clientele? How best should scarce resources be deployed to achieve results? This chapter reports on the results of several surveys conducted by Massachusetts, Iowa, New Jersey, and other states.

Determining pollution reductions, i.e., measuring the amount of pollution prevented, has always been an elusive goal. Traditional environmental monitoring of pollution depended largely on the proper technical skills and equipment. For years, EPA, state agencies, and companies measured only what came out of a pipe and into a single environmental medium like air or water. The technical challenge was to ensure that the end-of-pipe figures were accurate.

Measuring pollution that is *prevented* is much more difficult. With pollution prevention come industrial process changes, changes in the mix of chemicals used, changes in the products manufactured, and changes in production volume and markets. Determining how much pollution has been prevented and where in the multiple points in the industrial process such prevention occurred is a difficult task.

Nevertheless, significant progress has been made over the last five years in refining the measurement of pollution prevention, in studying the effectiveness of different types of pollution prevention programs, and in developing appropriate indicators of success in pollution prevention. Much remains to be done, and pressures on EPA and state governments to strengthen their measurement efforts have received new urgency from legislation and agreements, discussed below. This chapter explores why measurements of pollution prevention are important, discusses several of the measures commonly used, reports on the results of pollution prevention program evaluation studies, and outlines future directions and challenges in this area.

## The Emerging Framework for Measuring Prevention

One impetus for industrial facilities to measure the amount of pollution they create is obvious — pollution is waste, and waste is lost opportunity for profit. Businesses also measure in order to find the most efficient ways to comply with environmental regulations and to reduce the risks to workers' health and the potential for future environmental liabilities.

For government the simple answer to the question of “why measure?” is that until we know what impact prevention is having on the environment, it is impossible to judge the success of pollution prevention programs and to determine if and how they should be changed. Today the pressures to measure outcomes are greater than ever, as the federal government must comply with the Government Performance and Results Act of 1993 (GPRA) and state environmental leaders have, in exchange for EPA’s willingness to grant them flexibility in managing their programs, agreed to focus on measuring outcomes through the National Environmental Performance Partnership System (NEPPS).

### **The Government Performance and Results Act**

GPRA (also known as “The Results Act”) requires all federal agencies to:

- develop strategic plans prior to FY 1998
- prepare annual plans setting performance goals beginning with FY 1999
- report annually on actual performance compared to goals (the first report is due in March 2000)

The intent of this legislation is to place much greater emphasis on federal program execution — on outputs, outcomes, and results rather than inputs, program definition, and policy formation. Federal program managers will need to shift their focus away from activity-based measures of program performance and give greater attention to determining how well programs are meeting their objectives and what is being accomplished.

Generally, GPRA should improve the effectiveness and efficiency of federal programs, activities, and services. The heightened focus on performance should spur better performance. While reduced federal spending is not the stated purpose of this legislation, GPRA should lead to more effective expenditures as ineffective programs or activities are either improved or discontinued.

With respect to pollution prevention, EPA will need to increase its efforts in assessing the effectiveness of pollution prevention programs. States and companies that receive federal funding for pollution prevention activities should expect to be held more accountable for demonstrating the success of their programs. Performance levels will be tied to spending levels.

### **The National Environmental Performance Partnership System**

NEPPS, signed by the EPA Administrator and state environmental program leaders on May 17, 1995, is designed to give strong state programs more leeway to set environmental priorities, design new strategies, and manage their own programs, while concentrating EPA oversight and technical assistance on weaker programs. The major components of this agreement include increased use of environmental goals and indicators, state assessments of environmental program performance, environmental per-

formance agreements, and increased public involvement. This system envisions a trend toward state program self-management and flexibility, while improving environmental and programmatic accountability to Congress and the public.

A variety of measures will be used to gauge progress under NEPPS. Each state and its EPA regional office will agree on the set of measures that the state or EPA will collect and report during the year. There are three basic kinds of measures being used in tracking the progress of environmental programs: (1) environmental indicators, (2) “business” performance measures, and (3) program performance measures. Across all measures there are also two general classes of measures: (1) “outcome” measures, which show results in the environment or changes in behavior in the regulated community, and (2) “activity” measures, which track the various kinds of work done to achieve the desired outcome. The states and EPA are making a determined effort to focus on “outcomes” as much as possible, while tracking essential activities for internal management purposes.

Environmental indicators are viewed as the best, if long-term, way to measure meaningful progress in improving human health and the environment. All states participating in the new system are expected to use these measures to the fullest as a way of focusing program priorities on desired outcomes, and as a useful method of communicating results to the public. These indicators are expected to add a new and important dimension by helping to articulate long-term objectives and by showing the extent to which EPA and the states are making progress against those objectives.

Business performance measures are intended to capture behavior in the regulated community as they take actions to prevent or reduce health and/or environmental risks. In a sense, these are nearer term outcomes that can be measured by environmental agencies to gauge whether programs are having the desired effect. Some enforcement and compliance measures, such as compliance rates for individual businesses or industrial sectors, fall into this category.

Program performance measures are those outcomes or activities identified by each program that best reflect whether a program is being implemented as designed. In the past, these have been heavily weighted toward activity measures. Although it is recognized that there will always be a need for activity measures, EPA and the states are trying to strike a better balance between outcome and activity measures under the new system.

As part of the May 17 Agreement, EPA also agreed to “develop a limited number of program and multimedia performance measures on which each state will report.” In fulfillment of that commitment, each Assistant Administrator established a reduced set of program performance measures to pilot during FY 1996. These “core program performance measures” are the base minimum programmatic measures for regions and states to use in negotiating Environmental Performance Agreements. These measures applied to all participating pilot states for FY 1996. Environmental indicators will be added to this core set of program measures. Where states feel they have more appropriate measures, these measures can be added or substituted.

## Measuring Program Effectiveness in States and Communities

In this chapter, we discuss two ways to approach pollution prevention measures: measuring program effectiveness and measuring pollution reductions. Program effectiveness measures commonly are used by federal and state agencies to assess the overall impact of pollution prevention programs. Due to the challenges associated with determining overall statewide pollution prevention progress, many states have focused initially on measuring the success of specific state pollution prevention program components. In both cases, specific measures of pollution reductions achieved by implementing prevention programs are useful.

### Program Effectiveness Measures:

- Program Development
- Core Program Activity
- Outcome Measures
- Results Measures
- Goals Achievement

### Measuring the Effectiveness of Pollution Prevention Programs

Program effectiveness can be measured in a number of ways. The most straightforward are program development measures, answers to questions like, “How many states are implementing pollution prevention programs?” Beyond these simplistic measures are attempts to measure core program activity; programs might begin to ask questions like, “How many multi-media compliance inspections have we completed?” As programs mature, they might progress to asking outcome measure questions like, “What is the percentage of companies in a specific industry sector practicing prevention?” The next step would be to count result measures by asking, “How much cleaner is the air (or water or land) due to prevention in a particular industry sector targeting a particular set of chemicals?” And, finally, the ultimate goal of program effectiveness measurement is being able to answer specific goals achievement questions like, “What percentage of streams meet environmental quality criteria?” or “What is the total risk reduction to children from preventing exposure to chemical X?”

### Measuring the Effectiveness of State Pollution Prevention Program Components

Many state legislatures have established statewide goals for reductions in waste generation or toxics use — generally in conjunction with a pollution prevention facility planning requirement. In a number of these states, comprehensive measures of reduction in generation of wastes or use of toxic materials have been developed to evaluate the progress of the state’s pollution prevention program effort with respect to regulatory targets. However, evaluating the success of reaching this type of broad program goal is complex. Developing comparable measures that will allow such aggregation of data at the state level involves a variety of issues that have been dealt with in different ways by different states. For example, Massachusetts, which routinely collects data for materials accounting, was able to establish an aggregate index. In contrast, Washington, which lacks use and product data, chose gross business income as a surrogate index. Due to the many technical hurdles that must be overcome to obtain meaningful measures of overall statewide pollution prevention progress, many states have focused initially on measuring the success of specific state pollution prevention program components.

States, as well as independent research organizations, are determining the extent to which specific state pollution prevention program components are resulting in actual implementation of pollution prevention by facilities. To measure the benefits of state pollution prevention programs, evaluators are asking questions like:

- Is there a link between the state pollution prevention program elements and the pollution prevention measures being taken by the facilities?
- For technical services available from the state (e.g., on-site pollution prevention technical assistance, support for research, etc.), is there awareness among potential users of the availability of the services?
- How valuable or effective is a particular pollution prevention program component in causing facilities to implement pollution prevention measures?
- How can what we learn about program effectiveness be used to modify components of prevention programs so that they can lead to the development of more outcome-oriented pollution prevention measures by facilities?

Some evaluation studies isolate and measure particular aspects of these issues, while others try to link measurement elements together to gain a more comprehensive picture. Typical measurement methods, which can be used individually or in combination, include: analysis of records, reports, and plans; surveys or in-depth interviews (either broadly covering the universe of relevant facilities, or narrowly focused on recipients of specific services); focus groups; and case studies. The examples below further illustrate some of the approaches and issues in program evaluation.

### ***Facility Planning Evaluations***

New Jersey's Department of Environmental Protection (DEP) has undertaken several reviews of its pollution prevention facility planning requirement, from the standpoints of both effectiveness and benefit to the facilities. Through review and statistical analysis of information in facility pollution prevention plans and information provided by the facilities about the steps they had taken, DEP developed a summary of some of the initial program results as well as of the attitudes of businesses toward the planning requirement.<sup>1</sup>

The findings included information on projected trends in chemical use and non-product output generation, the processes and chemicals with the highest reduction percentage, and the relationship between previous planning experience and facility size and the scope of present objectives. For example, DEP found that 75 percent of the facilities had reduction goals greater than zero, and facilities that had undertaken previ-

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<sup>1</sup>Three sources were used to obtain this information: (1) New Jersey Office of Pollution Prevention. *Early Findings of the Pollution Prevention Program* (June 1995). Department of Environmental Protection, Trenton, New Jersey. (2) Hampshire Research Associates. *Evaluation of the Effectiveness of Pollution Prevention Planning in New Jersey: A Program-Based Evaluation* (May 1996). Alexandria, Virginia. (3) New Jersey Office of Pollution Prevention. *Industrial Pollution Prevention Trends in New Jersey* (December 1996). Department of Environmental Protection, Trenton, New Jersey.

ous planning efforts were likely to have more ambitious targets and better plans than other facilities. In addition, the facilities themselves confirmed that the planning process was beneficial: 74 percent of facilities thought the planning process worthwhile based on cost savings, reduced regulation, or other factors; two-thirds of the facilities indicated that some or all of their reduction projects were the result of the facility planning process.

Washington's Department of Ecology carried out a survey to determine: (1) the extent to which facility plans were leading to identification of pollution prevention opportunities; (2) the extent to which those opportunities were the result of the state's facility planning process; and (3) general attitudes toward the facility planning requirement on the part of industry.<sup>2</sup> A questionnaire was sent to 393 facilities, and 185 responded. In addition, in-depth telephone interviews were conducted with 13 facilities, and 12 facilities participated in focus groups. The study results included the following:

- Of the facilities surveyed, 96 percent identified in their plans, and were currently implementing, pollution prevention opportunities. In the interviews, over 50 percent said that the major opportunities had been decided upon or initiated before the planning process, though the process may in some cases have provided an additional push.
- The majority of facilities felt that they had already identified the major reduction opportunities, although minor opportunities might still exist.
- Many facilities objected to the more detailed quantification requirements of the planning process; sophisticated facilities, however, tended to find the planning requirement a paper exercise less detailed than internal management systems.
- Facilities had a very positive response to the Department of Ecology's technical support for the planning process (i.e., seminars, telephone support, on-site assistance).

Two studies have looked at facility planning in Massachusetts, using different survey- and interview-based techniques. In the first study, the Massachusetts Department of Environmental Protection (DEP) carried out inspections at 59 firms to determine: (1) whether facilities had met the planning requirement and (2) whether facilities regarded the planning exercise as useful. Of those inspected, 77 percent indicated that the planning process was useful, and 92 percent stated that they planned to implement toxics use reduction (TUR).<sup>3</sup>

A second study<sup>4</sup> examined whether the facility planning required under the Massachusetts Toxics Use Reduction Act (TURA) provided a means to encourage com-

<sup>2</sup>Ross and Associates. *Pollution Prevention Planning Effectiveness Study*. Prepared for Washington Department of Ecology (1995).

<sup>3</sup>Massachusetts DEP. Massachusetts Toxics Use Reduction Program (Presentation; 1995).

panies to integrate pollution prevention planning into their core business operations and planning processes. The study examined the perspectives and actions of environmental managers at 10 of the 21 companies in the paint and coating industry subject to TURA.

This study combined in-depth interviews with the companies' environmental managers with an evaluation of quantitative facility data (e.g., three-year history in generation of toxic pollutants, hazardous waste, and volatile organic compounds emissions). In addition, each company's past compliance history was reviewed to assess the potential for pollution prevention and the accuracy of information obtained from the interviews.

The study concluded that almost all of the environmental managers at these companies regarded the TUR planning process as simply another compliance requirement, although some felt that the process might nonetheless generate some useful information on environmental impacts, production processes, or environmental management costs.

### ***Technical Assistance Evaluations***

North Carolina measures the results of on-site visits with follow-up surveys of the facilities visited. The state uses the survey findings to shape subsequent program modifications. Specifically, North Carolina's Office of Waste Reduction sends out a survey form to facilities receiving on-site technical assistance. The specific pollution prevention actions recommended to the facility are listed, and the facility is asked whether it has implemented or plans to implement those measures. Where the measures have not been implemented, customers are asked to specify one of the following reasons: not technically feasible, low return on investment, payback period too long, would slow production, or better solution found.

The response rate to the survey from facilities served in FY 93-94 was 58 percent.<sup>5</sup> Of those responding to the survey, 96 percent had implemented at least one of the measures recommended. Overall, 56 percent of the recommended measures were implemented. The survey does not try to distinguish whether the implemented measures were already under consideration by the facility prior to the on-site visit. Information from the surveys has been used to alter and better target subsequent reports and recommendations resulting from on-site visits.

The Iowa Waste Reduction Center (IWRC), which works primarily with smaller businesses, uses follow-up telephone calls six months after all on-site pollution prevention technical assistance visits to determine which recommended measures have been implemented, as well as the resulting reductions in waste generation. This informa-

<sup>4</sup>Greiner, Timothy J. *The Environmental Manager's Perspective on Toxics Use Reduction Planning*, thesis for M.S. in Management and Master of City Planning degrees, Massachusetts Institute of Technology (June 1994).

<sup>5</sup>*North Carolina Office of Waste Reduction Follow-up Survey*. North Carolina Department of Environment, Health and Natural Resources; Division of Pollution Prevention and Environmental Assistance, FY 94-95 Annual Report, Appendix A.

tion is maintained in a database and is used to assess ways to modify the program. For example, the state recognized that implementation rates for pollution prevention changes involving higher capital outlays were low. Subsequently, a relationship was developed with the Iowa Small Business Development Centers to provide facilities with financial assistance.

IWRC also did a mail survey of 200 businesses that it had previously served.<sup>6</sup> The survey data were used to identify the types of recommended pollution prevention measures that small businesses have failed to implement and to determine the barriers that impede the implementation of these measures in order to refine future program efforts. The findings included the following:

- Input material changes (primarily switching to non-hazardous solvent) were implemented by only 24 percent of respondents, primarily because they were not convinced that the non-hazardous alternative would work as well as the hazardous solvent, or they perceived that they had too little time (or generated too little waste) to make the changes.
- Technology changes were only implemented 38 percent of the time. The reasons for this were too little time, too little waste to bother with the change, the cost of the equipment, or quality concerns.
- Suggestions to use and reuse hazardous materials were implemented 57 percent of the time. When not implemented, it was due to the cost of implementation, lack of knowledge, or too little waste.

The Massachusetts Office of Technical Assistance (OTA) utilized a telephone survey as well as in-depth, on-site interviews to assess the effectiveness of pollution prevention technical assistance provided as part of a pollution prevention project in central Massachusetts during 1989-1992.<sup>7</sup> The project focused on metal-using industries in the Upper Blackstone River watershed. Technical assistance offered under the project consisted of workshops, telephone assistance, on-site assistance, and financial analyses.

The survey consisted of telephone interviews of 110 companies. The sample was designed to provide a matched comparison of facilities inside and outside the project service area. In addition, 28 in-depth personal interviews were conducted at companies to evaluate their post-project assessments of the OTA effort. The results of the survey indicated that OTA activities had an impact on implementation of toxics use reduction measures as follows:

- Of the firms receiving on-site assistance from OTA or attending OTA workshops, 86 percent undertook toxics use reduction, as opposed to only 39 percent of similar firms in the same region.

<sup>6</sup>*An Evaluation of Small Business Pollution Prevention Assistance.* Small Business Pollution Prevention Center, University of Northern Iowa (June 1995).

<sup>7</sup>*Central Massachusetts Pollution Prevention Project: Summary Report.* Massachusetts Office of Technical Assistance (1994).

- The percentage reduction of chemical use inside the Central Massachusetts area was higher than outside.
- Over half the companies that attended OTA workshops or had on-site OTA assistance said that OTA influenced them to make reductions.
- OTA's clients were generally favorable about the usefulness of OTA assistance, with workshops and on-site assistance rated highest. Companies felt, however, that OTA needed more industry-specific technical expertise, and should do a better job of marketing its services.
- The cooperation of regulatory and non-regulatory agencies increased utilization of OTA services, resulting to some extent in two-thirds of the 40 site-visit requests received by OTA.

### **Community Efforts to Measure the Effectiveness of P2 Programs**

On a local scale, many communities are attempting to measure their progress in achieving pollution prevention goals. Most communities lack the resources to conduct large-scale assessments of pollution prevention programs like those described in the previous section. Communities can make these determinations by relying on indicators based on data gathered by local and state government agencies, academic institutions, and non-profit organizations. For example, data on waste generation and pollutant emissions could be used as indicators of pollution prevention progress. Hart Environmental Data compiled a database of indicators of sustainability that various communities have developed and used, alone or in combination, to measure their progress toward building sustainable communities.<sup>8</sup> They include:

- Air pollutants from stationary sources (used for Minnesota Milestones);
- Commercial waste generation (used for Toronto Healthy City);
- Compliance with dissolved oxygen standards (used for Jacksonville Quality Indicator);
- Good air quality days (used for Greenville Community Indicator);
- Percent of waste stream recycled (used for Pasadena Quality of Life Index);
- Pesticide usage (used for Toronto Healthy City);
- Solid waste generated/recycled (used for Sustainable Seattle); and
- Toxic chemicals released or transferred (used for Minnesota Milestones).

<sup>8</sup>Hart Environmental Data at <http://www.subjectmatters.com/indicators/>

## Measuring Pollution Prevented

A generalization can be made that there are only three outcomes for a toxic chemical once it enters a production process, and a case can be made that all three need to be tracked if pollution prevention is to be measured:

- The chemical can continue unchanged as an ingredient in a process or product.
- The chemical can be transformed into another chemical product (i.e., consumed).
- The chemical can wind up in the waste stream.

Three methods commonly are used to quantitatively measure the amount of pollution prevented: actual quantity change, adjusted quantity change, and materials accounting. Actual quantity change and adjusted quantity change focus only on chemicals that end up in the waste stream, whereas materials accounting takes product issues into consideration. The specific data requirements for these methods and their strengths and weaknesses as measurement tools are discussed further below.

### Actual Quantity Change (AQC)

One of the simplest and most common ways companies and governments measure pollution prevention is by calculating the difference in the actual quantities of hazardous waste generation between two time periods. Quantities may be specified in terms of volume, weight, or other units of measurement. The actual quantity change is an absolute measurement, calculated by subtracting the quantity of waste generated in the previous period or a specified baseline period from the volume in the current period.

AQC measurement is most often used when the goal is to get a sense of waste generation trends. It is easy to implement, uses data that are readily available, and can measure changes in chemical use or waste generation at the process, facility, state, or national levels.

Facilities subject to RCRA or TRI reporting requirements must keep track of hazardous waste generation or chemical releases before treatment, recycling, or disposal. These data can be used by the facility to calculate actual changes in hazardous waste generation and can be used to identify trends. Similarly, the data can be used at the state or federal level to measure actual quantities of toxic substances released into the environment and to identify broad trends in waste generation.

Measurement of actual quantity changes may give some indication of whether pollution is being prevented, but factors other than pollution prevention activities — such as a decrease in production or an increase in the amount of toxic chemical shipped in the product — could also result in a reduction in wastes generated.

## Adjusted Quantity Change

Measuring the adjusted quantity change separates the effects occurring as a result of changes in production from those occurring as a result of pollution prevention. Adjusted quantity change measurements are actual quantity change measurements adjusted or normalized by using a production or activity index. By adjusting for variations in production, the adjusted quantity change more closely measures pollution prevention efficiency than the actual quantity change measure defined above.

If a chemical is used at a facility for multiple purposes, different production indexes can be used for that chemical. TRI requires companies to file a production index for each toxic chemical the facility is required to report; however, the index is reported on a facility-wide basis. In cases where the chemical has multiple uses, it may not be meaningful to use a facility-wide production activity index. A study of New Jersey companies concluded that for more than 60 percent of the facilities, the facility-wide production index could not be used for pollution prevention index purposes.<sup>9</sup>

Facilities often have trouble constructing proper production indexes. The Washington State Department of Ecology has looked at plant level planning reports and TRI reports and has observed that the production indexes varied widely by facility and also within industry sectors. In some cases, the index used was not connected to the primary process that used the hazardous substance or generated the wastes. In many cases, especially in high technology sectors, products changed from one week to the next, making the determination of a single meaningful and comparable production index very challenging. In such cases, adequate definition of indexes is essential for obtaining accurate pollution prevention measurement.

## Materials Accounting

Materials accounting tracks specific chemicals as they move through the various steps and processes at a facility. Quantities of the chemicals are recorded at various locations on their path. Total inputs of the chemicals should generally equal total outputs; however, there is no requirement or standard applied to the level of “closure” or “balance” to be achieved. Materials accounting is a less intensive approach than a traditional “mass balance” where the degree of closure is very precise.

Data obtained through materials accounting (also referred to as throughput data) provide important information for measuring pollution prevention. The technique quantitatively tracks substances through a production process, and all materials entering the process must be accounted for upon leaving the process. No other environmental reporting system requires facilities to link material usage and products manufactured to waste generation and quantities released in the environment.

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<sup>9</sup>Hearne, Shelley. *Materials Accounting as a Potential Supplement to the Release Inventory For Pollution Prevention Measurement Purposes: A Case Study Analysis of New Jersey Throughput and TRI Data.*

### Materials Accounting in New Jersey

New Jersey's Department of Environmental Protection measured pollution prevention success using TRI data and facility-level materials accounting data, which New Jersey facilities are required by state law to submit. Measurements of waste generation based on the TRI data did not necessarily correspond to pollution prevention activities at the case study facilities. When materials accounting data were combined with the TRI data, a more comprehensive analysis of pollution prevention progress was obtained — reductions in quantities used were associated with pollution prevention activities.

Another important benefit of materials accounting is that it identifies how toxic chemicals end up, not just in wastes, but in manufactured products as well. For example, the INFORM *Toxics Watch 95* review of New Jersey materials accounting data found that of 124 million pounds of ozone depleting chemicals used as inputs statewide, only 3 percent (3.8 million pounds) ended up as waste.<sup>10</sup> In contrast, 58 percent (72 million pounds) of the input went to products containing the ozone depleters. This amount is much larger than the waste volume, which demonstrates the need to consider the entire product life cycle in order to get a comprehensive picture of the pathways of toxic pollutants.

The first half of a materials accounting analysis quantifies inputs to the facility and includes: (1) beginning chemical inventory; (2) quantity of chemical brought on-site; (3) quantity of chemical produced on-site; and (4) quantity of chemical recycled and reused. The second half of the materials accounting analysis quantifies outputs from the facility and includes: (1) quantity of chemical consumed; (2) quantity of chemical shipped as or in product; (3) quantity generated as non-product output; and (4) ending chemical inventory.

Materials accounting uses information that is collected routinely at facilities for business or inventory management purposes. Among these data are: records of shipments of raw materials into a facility and records of the specific amounts of chemicals in products. Materials accounting also uses data required by other environmental regulations, including manifest data required under RCRA.

Materials accounting can help identify pollution prevention opportunities within a facility. Pollution prevention requires a focus on sources of waste generation prior to recycling and treatment. Materials accounting provides the framework for tracking raw materials to the locations and activities where they are lost from the process, the point where money is lost and environmental problems begin. Attaching the full internal environmental cost to specific activities, rather than spreading the cost over an entire plant, can help justify expenditures on pollution prevention technologies.

In addition, materials accounting provides data for tracking trends in the levels of hazardous substances contained in products. Changes in plant operations that increase the level of hazardous substances into products can be identified. As mentioned previously, product data are necessary for measuring facility-level pollution prevention efforts. Products also can have environmental impacts once they leave the facility. In some cases, it may be waste streams at the consumer level that pose the greatest challenges for reducing the entry of toxic materials into the environment. The important role of products is reflected in the increasing use of life cycle assessment. These evaluations explicitly recognize that products must be followed beyond the plant gates in order to have a complete understanding of the potential for pollution.<sup>10</sup>

<sup>10</sup> U.S. EPA. 1994. Issue Paper #2. Expansion of the Toxics Release Inventory (TRI) to Gather Chemical Use Information: TRI-Phase 3. U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, Washington, D.C.

## Other Measures for Pollution Prevention

In addition to measuring the quantities of pollution prevented, efforts are being made to devise methods that will account for the varying degrees of hazard reduction when different wastes are reduced at facilities. Currently, there is no widely-accepted system for ranking the hazard potential of different chemicals, but work is in progress to create a measurement system that will take into account the fact that equal reductions in quantities of highly toxic substances and less toxic ones are not equivalent from a human health or environmental perspective. Recent efforts to develop a method that takes into account both toxicity change and quantity change are discussed below.

### Toxicity Change

Toxicity change, a risk-based measure, attempts to assess pollution prevention progress based on changes in the toxicity or other hazard for pollutants generated or released. The difficulty lies in ranking the relative risks posed by individual chemicals. Does the risk to workers exposed to chemicals outweigh the potentially harmful effects chemicals have on the environment? Should chemicals resulting in acute health effects receive priority over chemicals that may cause chronic health problems?

Some states and research institutions have developed rankings of the Degree of Hazard (DOH) of waste streams. These DOH systems are designed to categorize waste streams based on the risk posed to human health and the environment. They do not, however, measure pollution prevention in terms of quantities of pollution prevented.

### Combining Quantity Measurements with Hazard Values

Under a Pollution Prevention Incentives for States grant, the Indiana Pollution Prevention and Safe Materials Institute (IPPI) devised a pollution prevention measurement that incorporates hazard rankings for chemicals. This technique combines information on worker exposure and environmental hazard for each chemical to create a “hazard value” that is subsequently applied to the quantity of the chemical used or generated. First, a company must identify all hazardous chemicals used in a given process. For each chemical, the company then determines the amount used during specified periods, both before and after a pollution prevention strategy is implemented. These quantities are multiplied by the chemical’s “hazard value” to derive the “haz pounds” used of the chemical. The “haz pounds” for all chemicals used prior to pollution prevention implementation are then added together, and the result is divided by the units produced during this period. Likewise, all “haz pounds” of the chemicals used after pollution prevention implementation are totaled, and the result is divided by the units produced during the period. The two values are compared to determine whether the facility has achieved pollution prevention. IPPI is conducting field trials using this method at wood products, plastic, metal coating/plating, and automotive parts manufacturing facilities. In addition, research is being conducted to determine hazard values for more chemicals.

### **Environmental Accounting and Reporting System**

Polaroid Corporation uses a company-wide tracking system, the Environmental Accounting and Reporting System (EARS) to monitor progress of its Toxic Use and Waste Reduction Program. The EARS system tracks and quantifies materials at three critical source locations: (1) where materials are used; (2) where wastes are generated; and (3) when and how wastes leave the facility, including what happens to the wastes.

All materials used and generated at the facility (approximately 1,700 chemicals) are grouped into five broad categories based on potential risk. The EARS system tracks and quantifies materials at different locations (e.g., input or output) for each risk category. The preferred reduction approach (e.g., use reduction, source reduction, recycling, etc.) also varies based on the risk level. For example, category I and II chemicals, which are human/animal carcinogens with known chronic toxicity, should be measured during input and controlled via use reduction.

### **Future Directions and Conclusions**

The information presented in this chapter documents how pollution prevention has been measured by companies and local, state, and federal governments both in terms of pollution reductions and program effectiveness. The chapter provides a broad indication of the measurement options available to companies and government agencies involved in pollution prevention. However, a number of questions still must be answered before we can fully determine how well we are doing nationally in preventing pollution. These questions include:

- Is measurement comprehensive? Is it able to capture outcomes when source reduction techniques are used?
- Does measurement account for production changes?
- Does measurement allow for tracking of facility performance over time?
- Does measurement allow for meaningful comparisons of two or more similar facilities?
- Does measurement support aggregation of performance of several facilities in a state or industry sector?

The federal government is under increasing pressure to eliminate federal programs that are not successful, which has contributed to a growing urgency in the need for adequate measures of pollution prevention program effectiveness. In addition, the federal government is granting more regulatory flexibility to states. With this increased flexibility, however, comes greater responsibility on the part of states to demonstrate that they are still meeting environmental goals and objectives. To this end, many states are incorporating measures of program success into their project proposals. For example, San Diego's proposed Community XL Project would shift environ-

mental regulation of San Diego Bay businesses and industries away from traditional end-of-pipe strategies toward greater emphasis on pollution prevention. The proposal contains detailed plans for measuring program success using several types of evaluation measures. Quantitative measures will center on documenting cost savings and waste reductions. A pollution prevention index will compare key environmental and economic indicators. The index is a ratio of the quantity of pollutant discharged to the level of economic activity.

The implementation of GPRA and NEPPS will contribute to a fundamental shift in how pollution programs are evaluated in the future. For example, the majority of state pollution prevention programs currently account for resources expended simply by tracking the level of activity of the program. With GPRA, however, the emphasis is on program performance (e.g., environmental benefits). Under NEPPS, the states and EPA also are focusing on programs outcomes as much as possible. This increased emphasis on actual performance of pollution prevention programs should lead to the development of more effective pollution prevention measures in the years to come.



## Measuring Pollution Prevention Progress

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*"I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind, it may be the beginning of knowledge, but you have scarcely in your thoughts, advanced to the stage of Science whatever the matter may be."*

*- Lord Kelvin*

We measure things to understand them, to account for them, and to manage them and improve their performance. When we operate industrial production facilities, we take things from the environment; convert, manufacture, and assemble these things; and send them out as products and services that make our lives better. We also send out the wastes, effluents, and emissions that are the residual byproducts of production. In order to justify the benefit of industry we must ensure that the risks to the environment and our health do not outweigh the benefits of products and services.

Measurement is the bedrock of science. We can not understand the relationship between industrial activity and environmental quality if we do not measure industrial impacts and do not seek out and study possible effects. Plotting trends in indicators of terrestrial, marine or atmospheric chemistry and biology provides a means of understanding the consequences of anthropocentric activities. Similarly, tracking indicators of industrial activity provides knowledge of the sources of contaminants. Studying the effects of heavy metals in aquatic environments or the interactions of volatile compounds in the atmosphere increases our knowledge, but it is only when we can correlate those effects with their releases from generators that we understand how we affect the environment.

Preventing pollution is a complex process requiring an understanding of production systems, industrial technologies, control apparatus, operational efficiencies, market conditions, regulatory requirements, and the fate of substances in the various sectors of the environment. Defining adequate indicators of pollution and meaningful indices of prevention is not trivial. Measuring something that exists, such as pollution, is always easier than mea-

asuring that which has been prevented. In addition, the wide variations in generators, the differences among pollutants, the diverse methods of collecting data, and the differing baselines from which companies begin measuring mean that there will be no simplistic or singular way to measure pollution prevention. Yet, pollution prevention does require some common coherence that is only recently emerging. This will require a documented body of experience and practice, a consensus on terms and definitions, a set of replicable data collection methodologies, and stable and understandable methods of analysis.

Measurement provides the foundation for accountability. The policy transition from pollution control to pollution prevention reconfigures the conventional relationship between industry and government from an adversarial, compliance-oriented system to a more cooperative system of shared responsibilities. Improving the environmental performance of firms has become an environmental program in the same way that improving childhood reading scores is an educational program. Like government-sponsored reading advancement programs, government-sponsored pollution prevention programs require public accountability and accountability requires the periodic assessment of progress. Public investment in pollution prevention engenders a responsibility to measure and assess progress.

Recent state and national experiments with alternative means of assuring environmental performance from industrial facilities rely less on permit writing and compliance. These programs must still guarantee a credible means of accountability. Self-reporting and third party audits require some commonly accepted metrics. While the performance indices in early demonstrations may vary significantly, as programs stabilize and mature they will require measurement systems that are consistent, focused and self-validating. Environmental protection programs that are flexible and well tailored to facility capacities will still need measurement systems that assure the public that pollution is reduced and environment quality is improved.

Finally, measurement is the key to managing and improving what we make. There is an old quote: “If you can’t measure it; you can’t manage it.” Preventing pollution, like optimizing production, is fundamentally a management problem. There will be new technologies and new materials that offer opportunities for more environmentally-conscious manufacturing, but selecting these and employing them to their greatest advantage will be determined by management. Leading firms today identify opportunities to reduce pollution, calculate savings, convert systems and evaluate effectiveness by maintaining and analyzing data collection systems. Like quality assurance systems and loss control procedures these pollution prevention systems require setting goals and measuring progress.

A good facility pollution prevention system should build recognition, validation and learning into the daily practice of data collection. Nor should measuring pollution prevention be an isolated endeavor. Data collection that is not integrated into the techniques of production management and business accounting will always appear as a conceptual and financial burden. Like the speedometer on a car, an effective measurement system needs to collect data naturally from the functioning of the process, report it in a timely manner, and provide a feedback loop that encourages analysis and correction.

The responsibility to measure and assess pollution prevention programs is driven by several commitments—the need to promote progress, the need to validate performance, the need to appropriately target public investment, the need to inform the public—but, primarily, it ensures that the public trust upon which environmental protection must be based, can be achieved without the imposition of government authority. To promote pollution prevention without metrics and without goals for measurement would promote activity instead of movement and reward effort instead of achievement. Constructing valid and appropriate systems for measuring pollution prevention progress is critical to the further development of this young field.

